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MuSeK

Integrated modelling of the future electricity and gas supply in Germany

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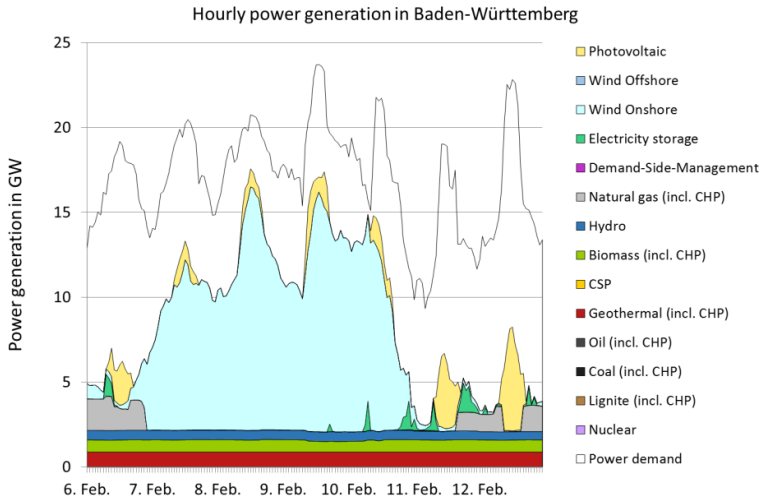
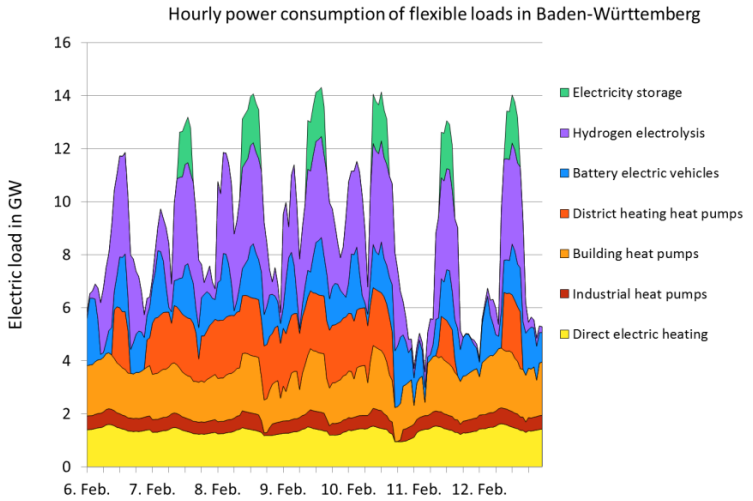
Energy Systems Analysis

DLR

Research interest

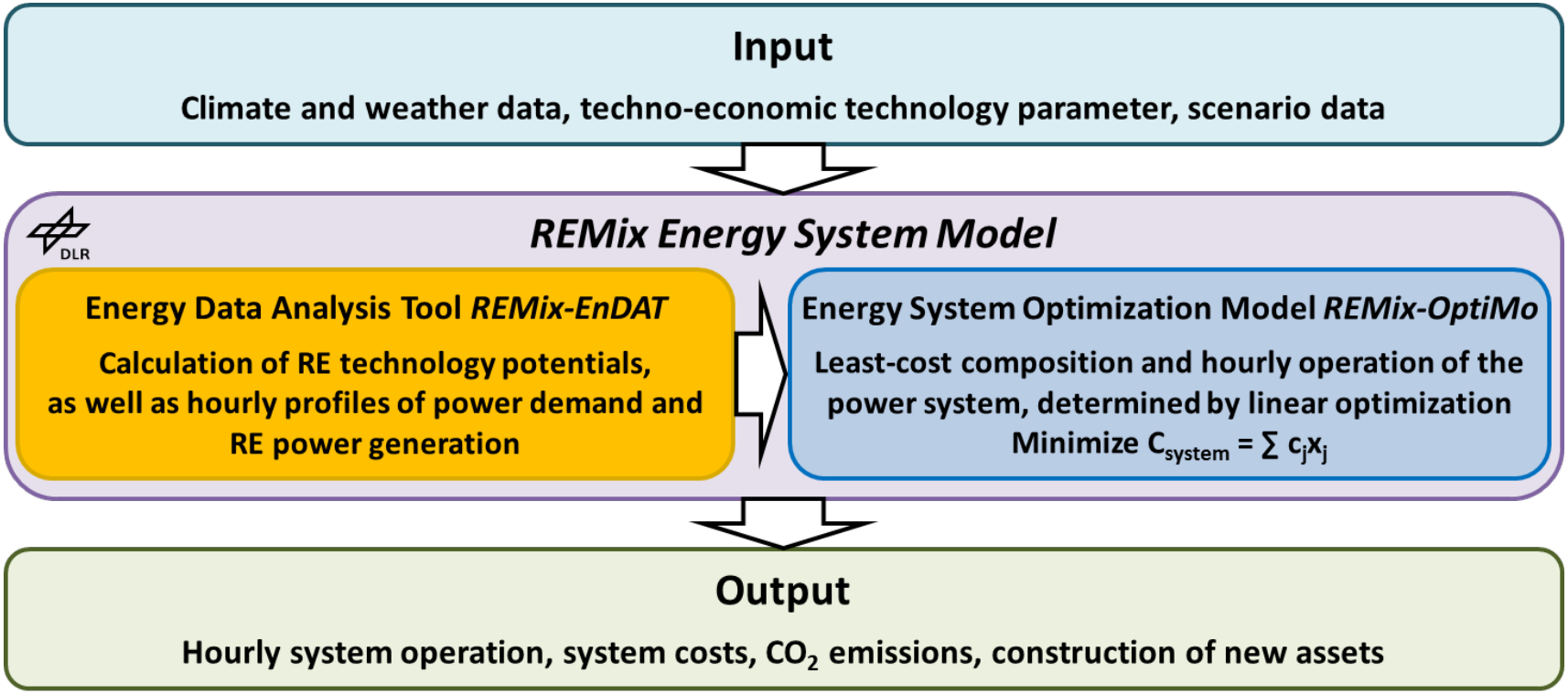
- Evaluation of flexibility in integrated and sustainable energy systems
- In MuSeKo: Contribution of synthetic gases to the system transformation
  - Importance of flexibility in the production of these gases
  - Interaction with other flexibility options
  - Identification of the least-cost dimensioning of converters and storages
  - Analysis of the flexibility of the electrical equipment in the gas network





Source: Schick, C. et al. (2018) Energiesystemanalyse Baden-Württemberg. Project report, http://www.strise.de/projekte/

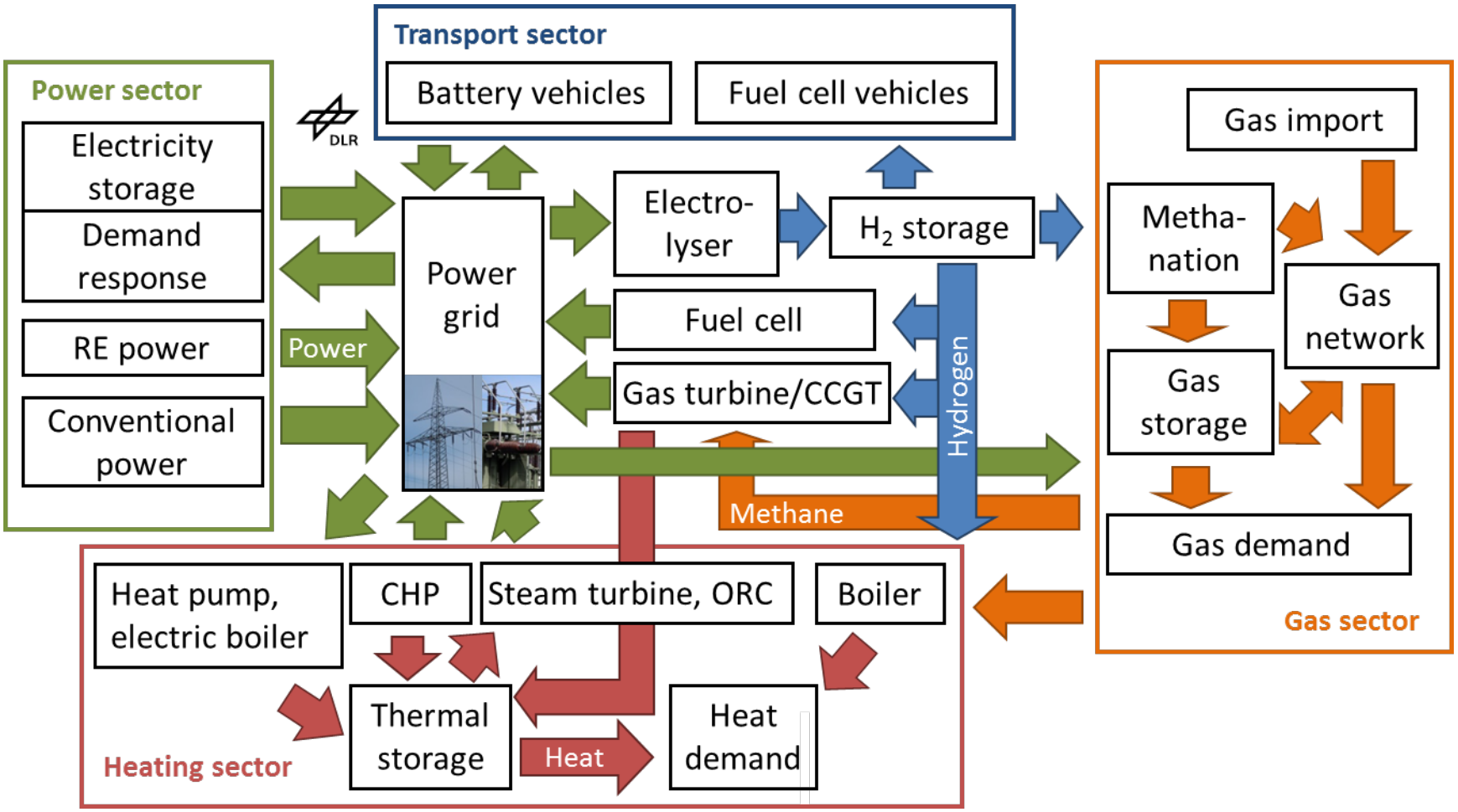
REMix energy system model



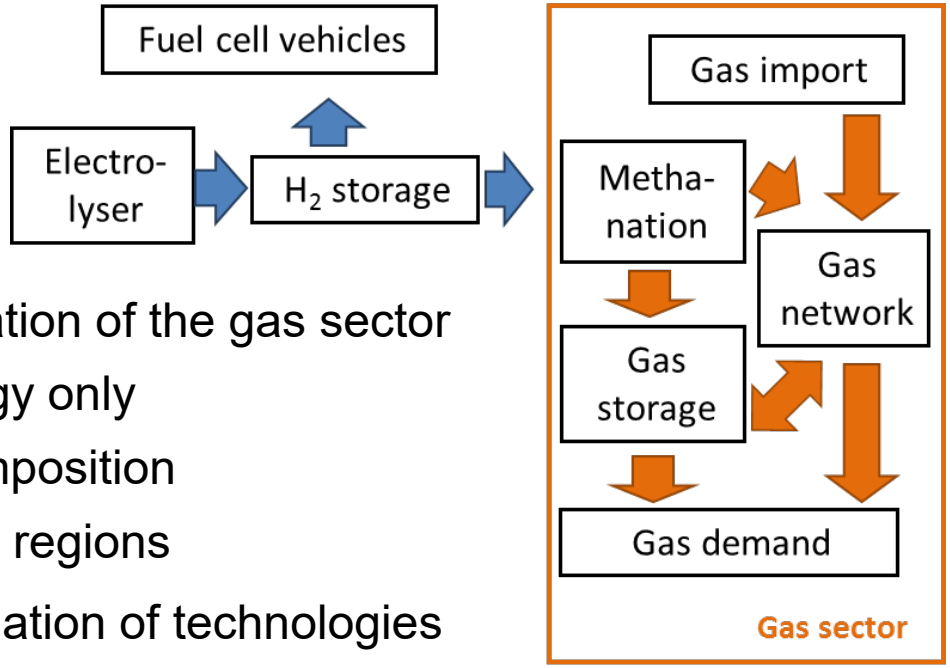
- Cost-minimizing model from an economic planner's perspective
- Hourly resolution, typically perfect foresight for one year (8760 time steps)
- Simultaneous optimization of plant expansion and operation

Source: Gils, H.C, Scholz, Y., Pregger, T., Luca de Tena, D., Heide, D. (2017) Integrated modelling of variable renewable energy-based power supply in Europe. Energy, 123: 173-188. http://dx.doi.org/10.1016/j.energy.2017.01.115

Evaluation of flexible energy sector coupling with REMix



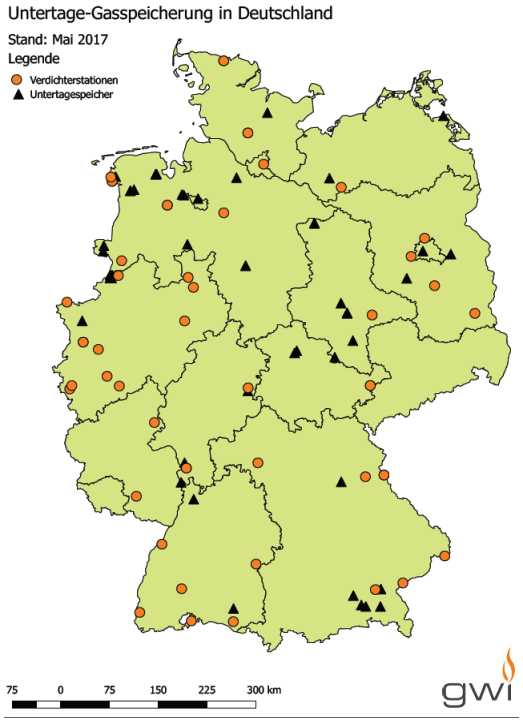
REMix enhancement for the gas sector

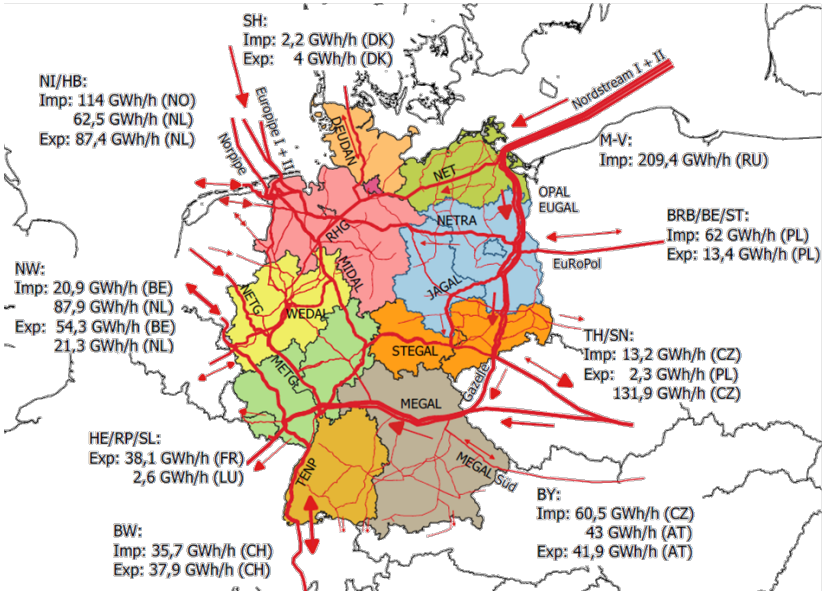


- Goal: reduced, linearized representation of the gas sector
  - Consideration of chemical energy only
  - No consideration of the gas composition
  - Aggregation according to model regions
- Modular structure for flexible combination of technologies
- Generic modules representing similar technologies
- Simplified modelling of gas transport between the model regions
- Compression in pipelines and storages with gas or electricity (endogenous)
- Optional feeding of hydrogen and biogas into the natural gas system

Data basis for the gas system modelling in MuSeKo

- Salt domes for CH_4 or H_2 storage
- Data on existing assets: storage locations and capacities
- Evaluation of gas transport capacities
- Assumption of reversible flows
- Compressor capacities from literature and inquiries





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REMix configuration in MuSeKo

- Myopic application: 2020, 2030, 2040, 2050
  - Capacity installation transferred to subsequent years
  - Decommissioning at end of lifetime
  - No construction time
- Consideration of existing capacities:
  - Power/Gas network and storage
  - Wind/PV capacity w/o decommissioning
  - CHP/conventional capacity w/ decommissioning
- Capacity optimisation of RE, gas power plants, CHP and electricity storage
- Capacity optimisation of flexible sector coupling
- Limited power grid expansion only from 2040 on

Scenarios in MuSeKo

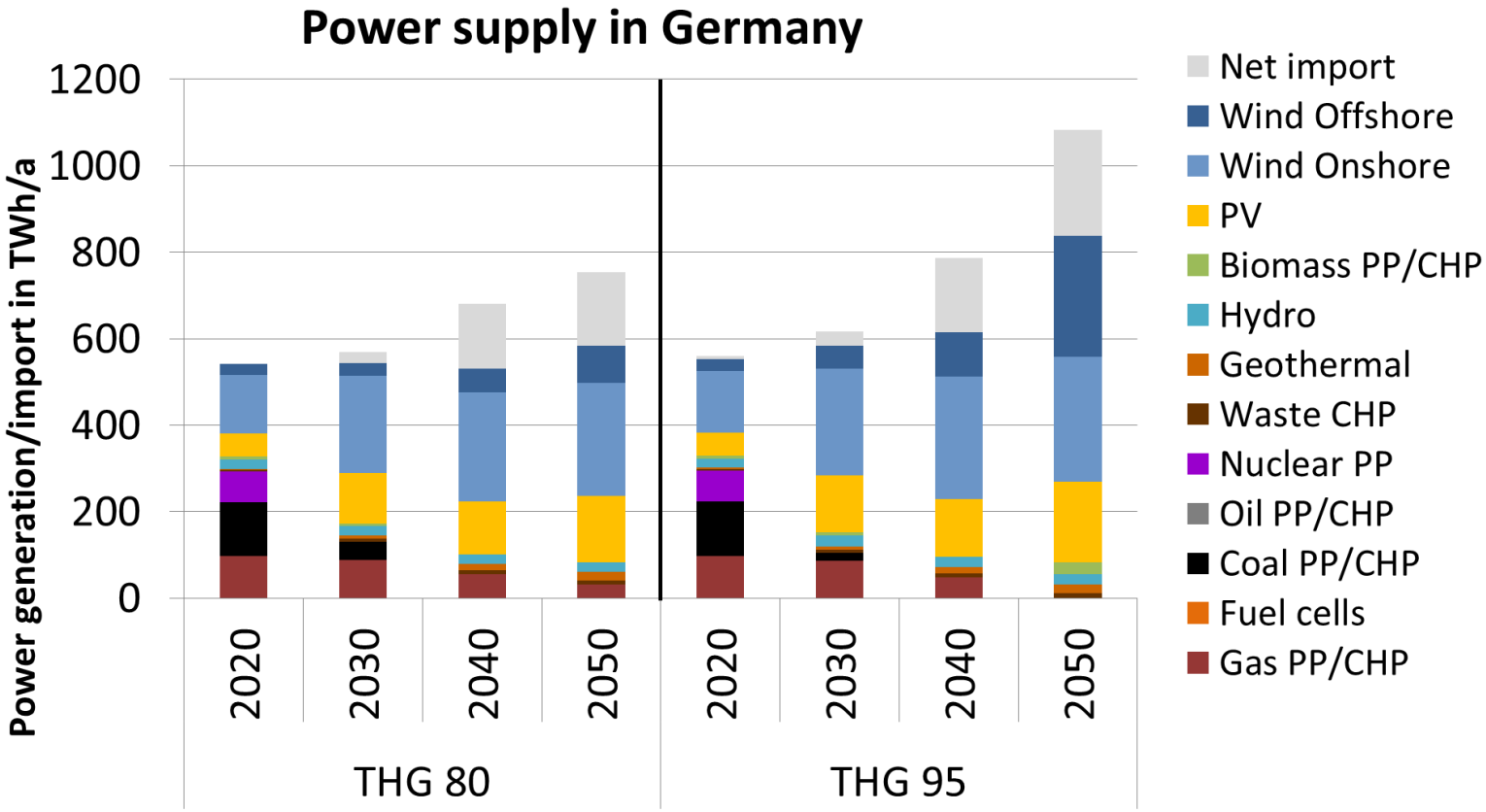
THG80 (80% CO_2 reduction)

- Exogenously defined demand for power, CH_4, H_2 and heat
- Exogenously defined fuel and CO_2 emissions costs

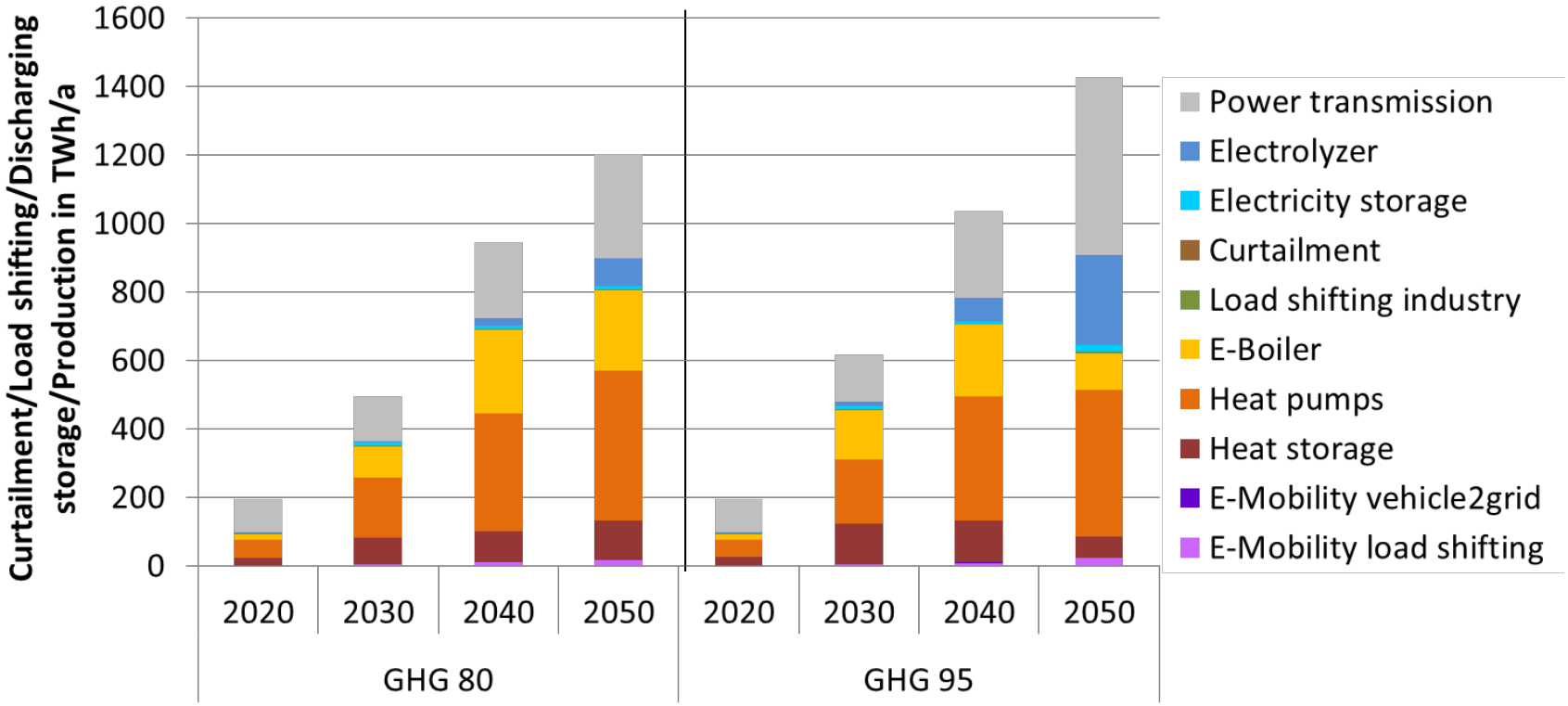
THG95 (95% CO_2 reduction)

- Higher CO_2 emission costs
- Increased power and H_2 demand in transport and heat sectors

Development of power supply 2020 – 2050

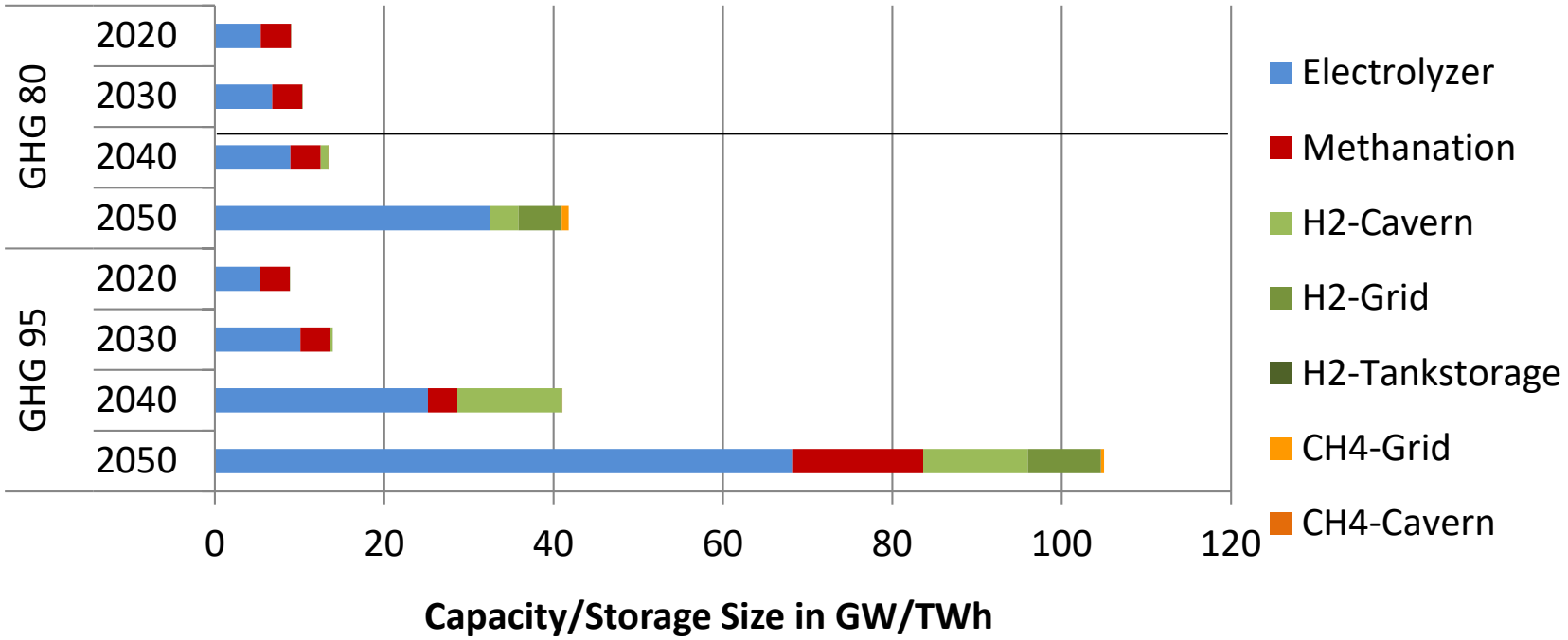


Load balancing through various flexibility options

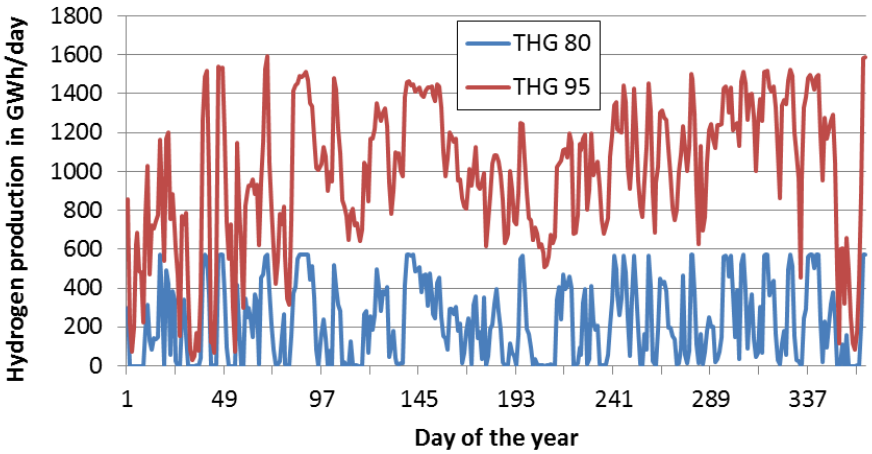


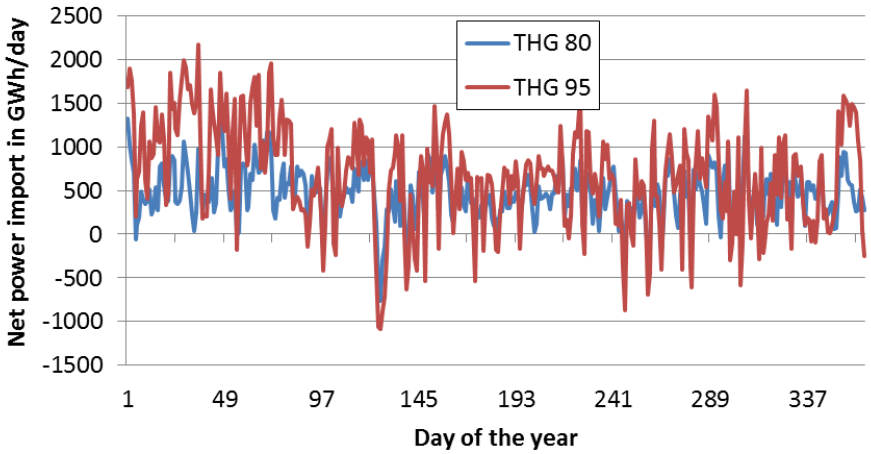
Preliminary results:
do not cite or distribute

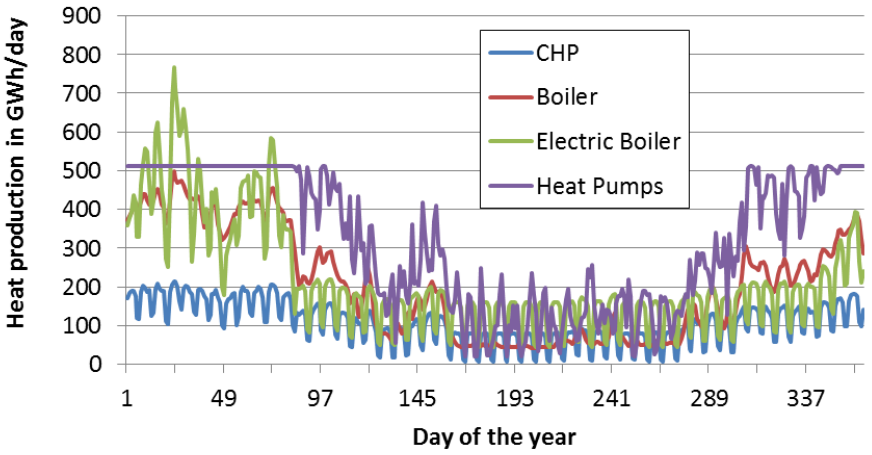
Development of the gas sector in Germany



Balancing of weekly fluctuations

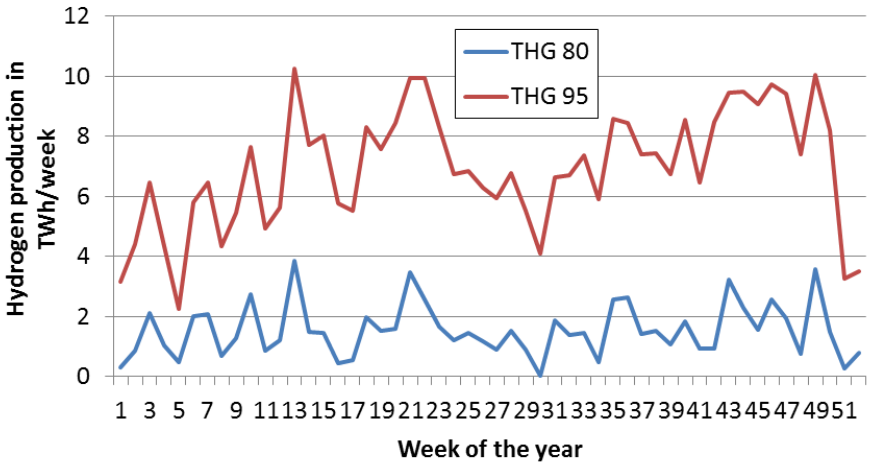


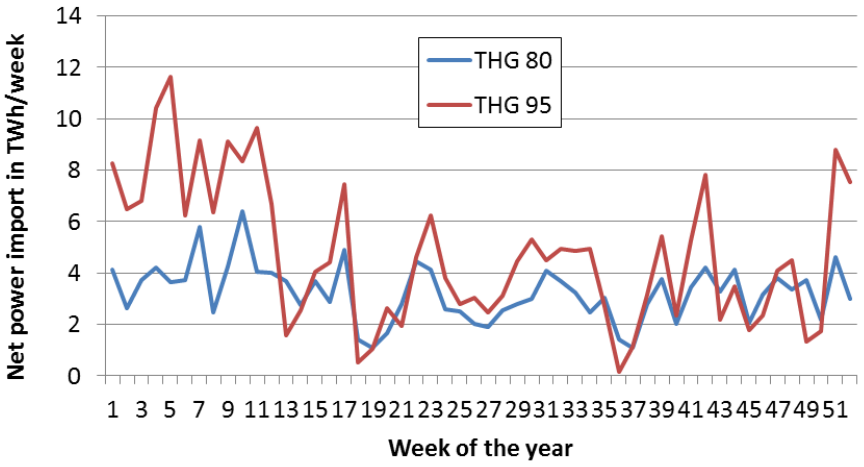


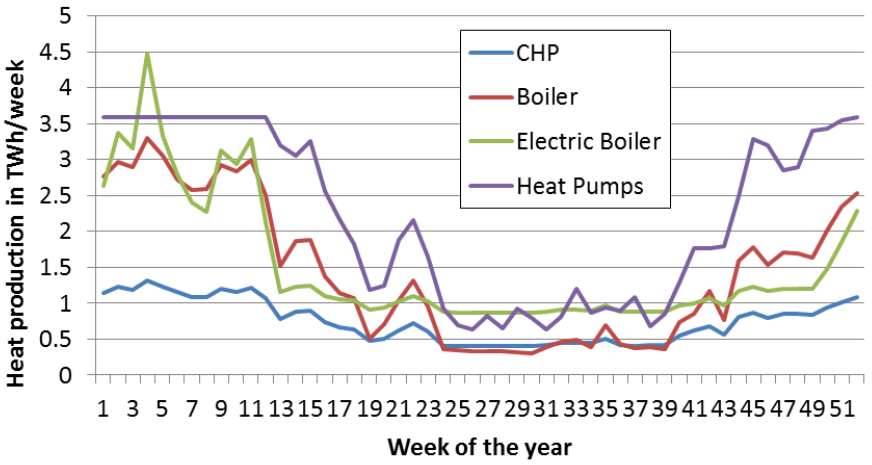


- High volatility in hydrogen (and methane) production
- Residual CHP operation driven by industrial demand
- Thermal energy storage buffers wind generation peaks

Balancing of seasonal fluctuations







- Seasonal hydrogen storage becomes relevant in THG 95
- Heat pumps provide base load for district heating in winter

Summary

- Integrated consideration of all sector coupling options desirable
- Simplified representation of the gas sector improves analysis capabilities
- Options of flexible sector coupling interact positively with each other
- Flexible H_2 production can make a significant contribution to RE balancing
- Partial conversion of natural gas infrastructure to H_2 is an attractive option
- Methanation and seasonal storage become relevant in THG 95 scenario

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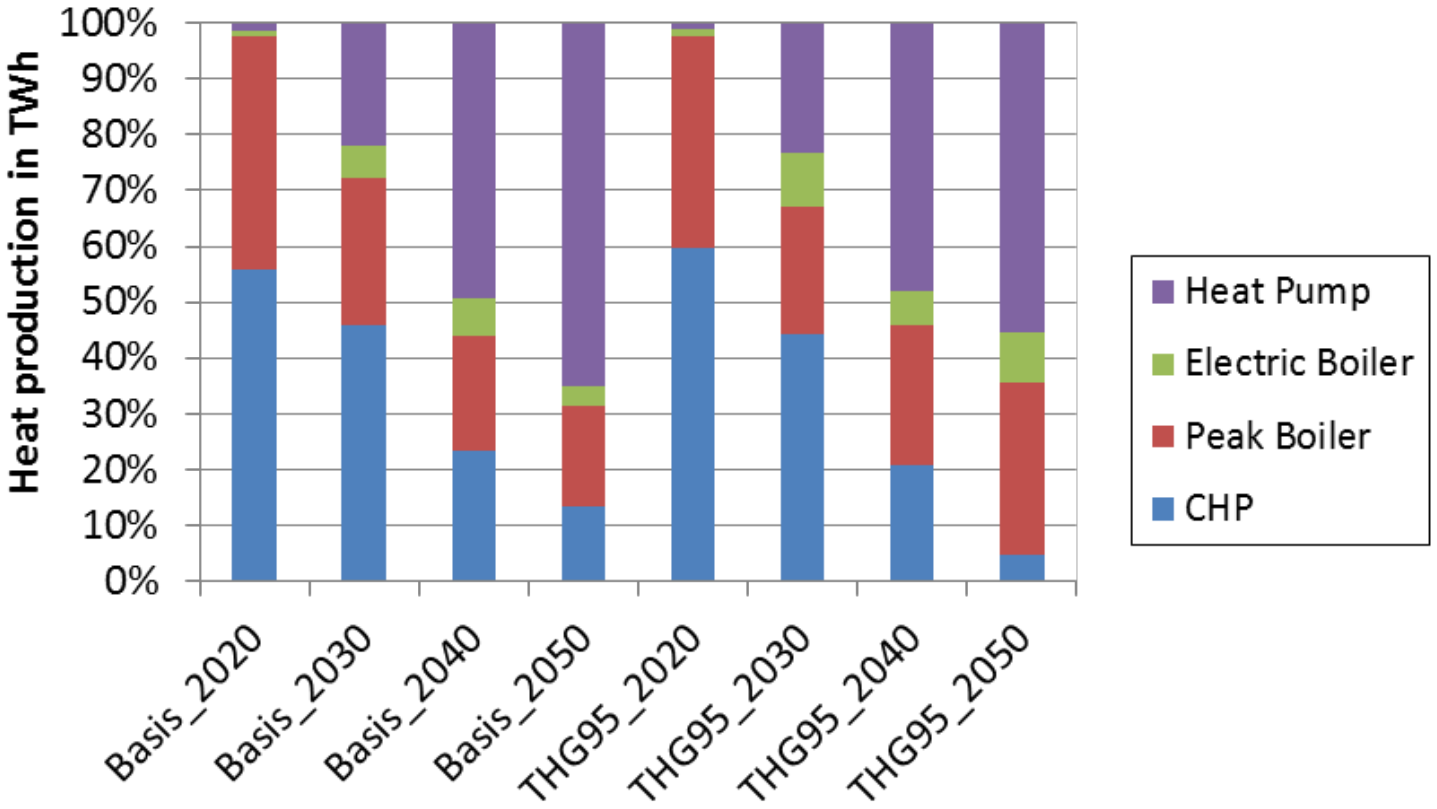
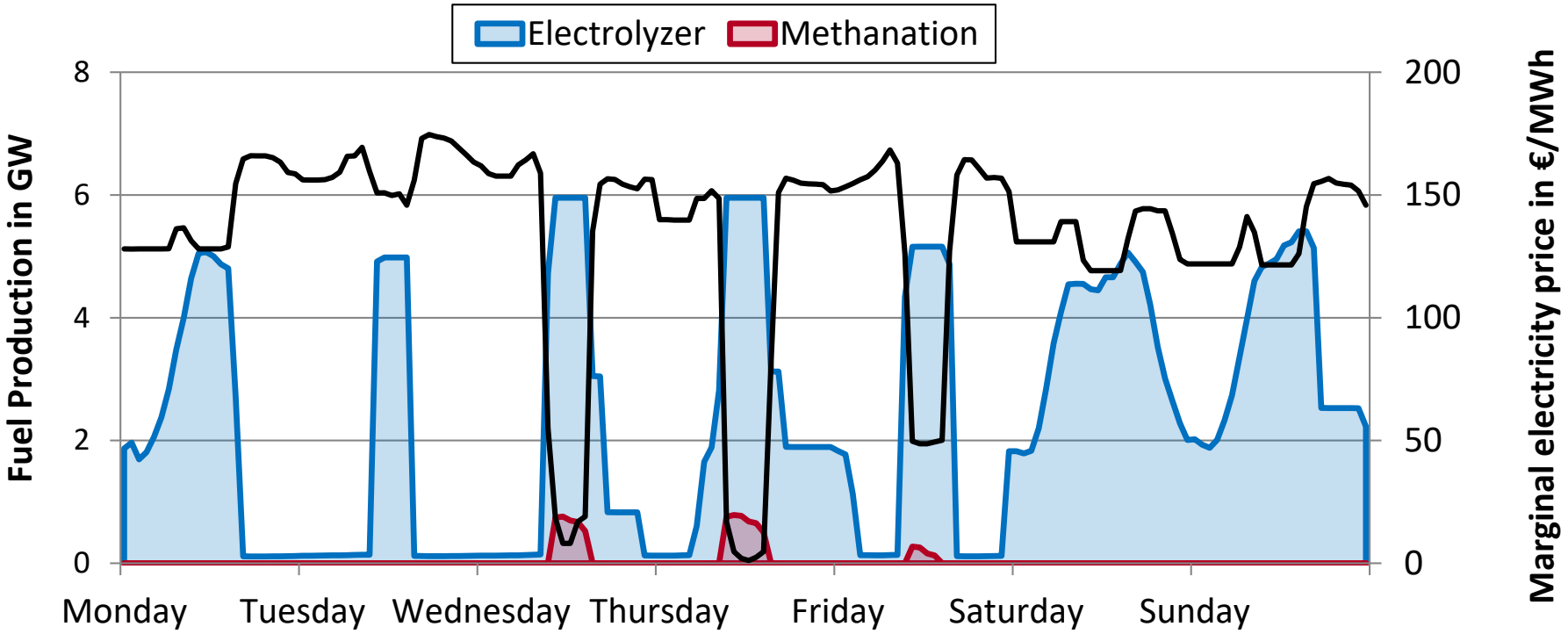
Transformation of district heat supply



Synthetic fuel production (GHG 95)



Behaviour of gas sector components